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A COMPARISON OF TRAINING METHODS, TYPE OF PROBLEM, AND APPARATUS IN ACQUISITION AND EXTINCTION.

by

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A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES
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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "A Comparison of Training Methods, Type of Problem, and Apparatus in Acquisition and Extinction", submitted by Eileen Margaret Towart in partial fulfillment of the requirements for the degree of Master of Science.

Abstract

In a 4 x 2 x 2 x 2 randomized groups design, a study was made of correction, rerun correction, noncorrection and rerun noncorrection training methods in the acquisition and extinction of a position response and brightness discrimination in a parallel alley maze and T-maze using preference and nonpreference conditions. Four dependent variables were rigorously defined--trials, errors, correct responses, and runs. In acquisition, the factors--training methods, tasks, and preference were found significant. Extinction results showed no significant differences. Learning occurred for all *S*s with *S*s in NC requiring fewer reinforcements to reach the criterion. It was generally concluded that the use of one of the noncorrection procedures will likely give more efficient learning of similar tasks in terms of the defined dependent variables. Rigorous definition of methods and variables will permit comparison between and in future studies.

Acknowledgements

I would like to extend my sincere appreciation to Dr. W. A. S. Smith who supervised this investigation and to the other members of my committee; Dr. R. Walley and Dr. S. Rule for their helpful suggestions.

Eileen Margaret Towart.

To

my parents

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Introduction

During the past two decades there have been numerous studies in different areas of maze learning (e.g., acquisition of a position response, a discrimination task). Within these areas, various training methods have been used and often different results have occurred with similar problems. There have been four basic training methods used when a S makes an error in learning a maze. Usually only two of these have been compared in any one study. An exception to this is the series of studies by Kalish (1946). However, although all four methods were compared, this was not accomplished in one all encompassing experiment. Furthermore, there has been only one study (Towart & Boe, 1965) in which explicit definition of the four methods has been made. In this study, these methods were defined as follows:

1. Correction method (C). Following an error, the S returns to the choice point and makes another choice. A trial is completed after the correct choice is made.
2. Rerun correction method (R-C). Following an error, the S returns to the choice point and makes another choice; when the correct choice is made, the S is returned to the start point and another run commences. The first errorless run completes a trial.
3. Noncorrection method (NC). Following an error, the S is prevented from returning to the choice point. A trial is completed upon the commission of an error or correct choice.
4. Rerun noncorrection method (R-NC). Following an error, the S is prevented from returning to the choice point, and is returned

to the start point where another run commences. The first errorless run completes a trial.

Two investigations (Muenzinger & Powloski, 1951; Towart & Boe, 1965) compared C with R-NC which is relevant to an evaluation of C because the number of reinforcements is the same in both instances. Comparisons between C and NC (Besch, Morris, & Levine, 1963; Hull & Spence, 1938; North, 1950a; North, 1950b; Parducci & Polt, 1958; Seward, 1943) have shown learning in both groups even though Ss in C received a larger number of reinforcements than those in NC.

Kalish (1946) compared the four methods of training with rats in an H-maze. A S started, for example, at one end of the left section and was required to run to the opposite end of the right section. The start point was varied from the upper to the lower end of the left section. No evidence of learning the correct turn at the intersection of the cross section and the right section was evident in the C group; evidence of learning in the NC group was found after many trials; the criterion of learning was met by Ss in the R-C and R-NC groups, with the R-NC group learning in fewer trials and with fewer errors.

In the comparison of C with R-NC, Muenzinger and Powloski (1951) found that rats acquired a light/dark discrimination in a T-maze significantly faster by C. This result is opposite to that found by Kalish (1946) with rats under different conditions, e.g., task and apparatus differences. The investigations carried out by Towart

and Boe (1965) showed no significant differences between C and R-NC in the acquisition of a position response in a parallel alley maze. However, in a series of six position reversals, R-NC was found to be superior to C. It was tentatively concluded that the superiority of one method over the other during acquisition depends on the nature of the task.

Kalish's (1946) finding that NC is superior to C, in spite of fewer reinforcements, was also observed in rats learning a position response in a T-maze by Seward (1943), in rats trained in a T-maze to different reinforcement schedules by Parducci and Polt (1958), and in rats learning a drive discrimination in a T-maze by Besch et al (1963). However, Hull and Spence (1938) found little difference in terms of errors between C and NC during acquisition of a position response by rats in a T-maze although the NC group acquired the habit with fewer reinforcements. No tests of significance were reported for these data, however. Then, after a standard number of trials for all Ss, the position response was reversed. The results showed fewer errors during reversal learning for the C group, although the NC group reached the same level of performance with fewer reinforcements. In a series of 48 reversals of a position response in a T-maze, North (1950a; 1950b) found no significant difference in errors between C and NC groups during reversal learning. The C group received about half again as many reinforcements as the NC group. The position response was reversed after a set number of trials, not after a performance criterion had been attained. In general, the results of these experiments showed that NC yields more rapid learning of a single choice point maze by rats than C.

Inasmuch as the experiments (Kalish, 1946; Muenzinger & Powloski, 1951; Towart & Boe, 1965) comparing C with R-NC produced conflicting results and yet were similar in most respects except for task and apparatus (Kalish--delayed reaction problem in H-maze; Muenzinger and Powloski--brightness discrimination in T-maze; Towart and Boe--position response in parallel alley maze) it is evident that further study is required before any general statement of their relative merits can be made. Furthermore, Towart and Boe (1965) suggested that systematic study of the influence of training methods could be of considerable importance in the selection of training method in learning experiments. It has been demonstrated in several pairs of experiments (e.g., Blodgett & McCutchan, 1944 vs. Kalish, 1946; Wischner, 1947 vs. Muenzinger & Powloski, 1951) that very different conclusions can be reached about the same problem when different methods of training are used.

The purpose of this study, therefore, was to experimentally compare the four methods of training in two apparatus designs (the parallel alley and T-mazes) and in two learning situations (acquisition of a position response and a brightness discrimination). The influence of training to preference or nonpreference was introduced as a factor which may affect the efficiency of a training method under certain conditions. Thus several questions were considered:

1. Is there a difference between training methods?
2. Does apparatus design influence the efficiency of training methods?

3. Do training methods differ in efficiency for different tasks?
4. Does the number of reinforcements received by the Ss influence results?
5. What effect does training to a preference or a nonpreference have on results? Is there any interaction with training methods?
6. If a difference between training methods is attained in acquisition, will the extinction of this response show similar differences?

In the latter problem NC was the extinction method because essentially all Ss would be using this during the last two days of acquisition (criterion days). The present investigation extends the conditions under which the four methods of training have been compared.

Method

Subjects

The Ss were 96 experimentally naive male albino rats from a local supplier (N. A. T. Lab Co.) approximately 90 days old at the beginning of the experiment. All Ss were individually caged in the experimental room under constant artificial illumination.

Apparatus

One apparatus was the parallel alley maze illustrated in Fig. 1 and scale drawing, Fig. 2. It was constructed of wood, painted flat black, with hinged lids of hardware cloth on top and lights shielded by "flashed opal" glass. The second apparatus was the T-maze illustrated in Fig. 3 and scale drawing, Fig. 4. This was built to the same specifications as the parallel alley maze and constructed of the same materials. The only major difference between the two mazes was the position of the goal boxes in relation to the choice compartment. In the T-maze, the alleys to the goal boxes were at 180 degrees to each other. A glass furniture coaster in each goal box served as water cups.

The E observed the Ss' behavior and operated the guillotine doors in each maze from behind a partition which prevented his movements from being seen by the Ss.

Design

The study used a 4 x 2 x 2 x 2 randomized groups design with three replications. The 32 Ss in each replication were randomly

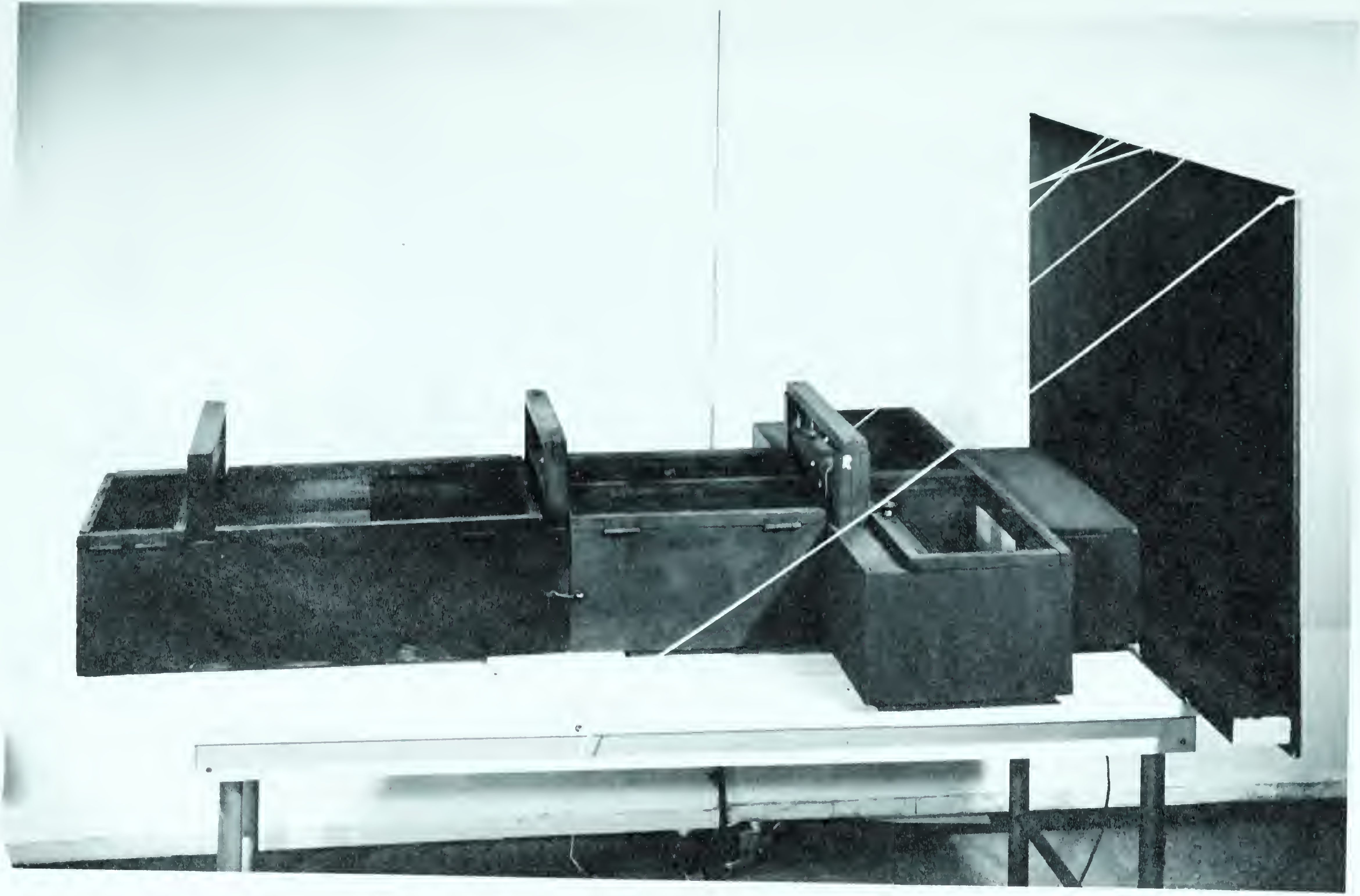

Fig. 1. The parallel alley maze and shield behind which the E operated the guillotine doors

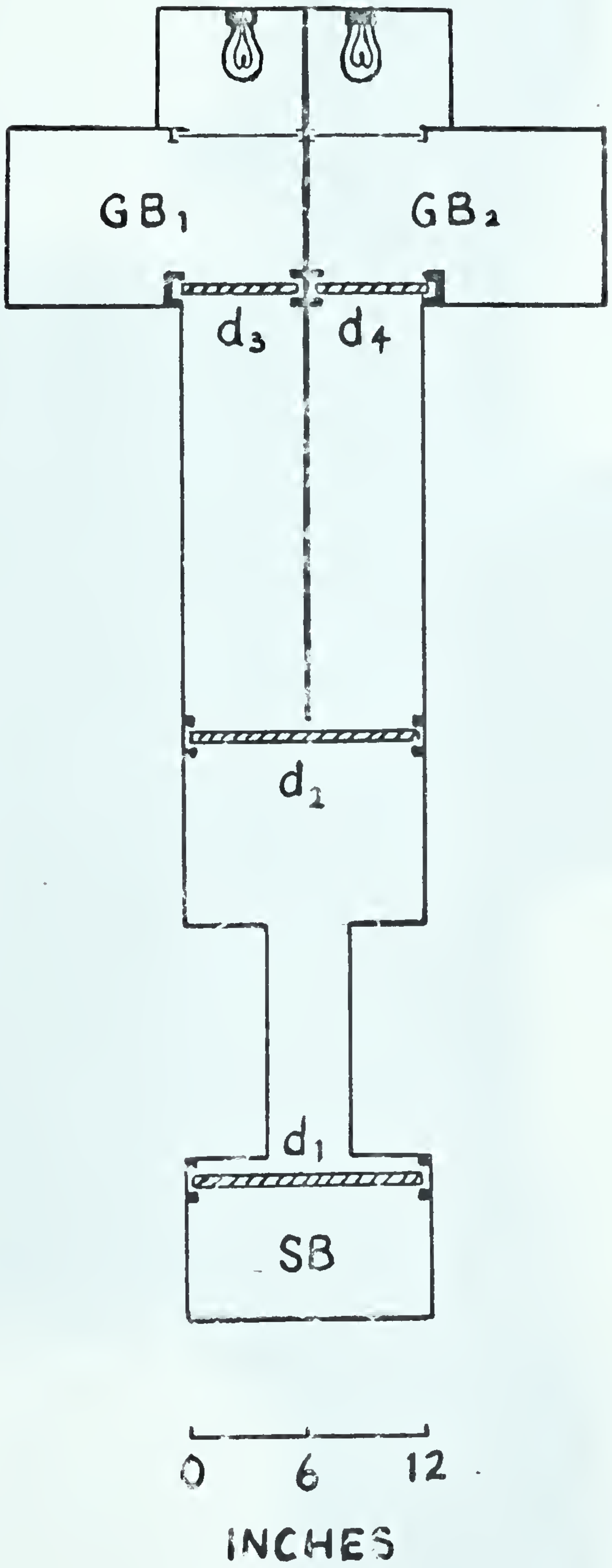

Fig. 2. Scale drawing of the parallel alley maze. SB = start box; GB = goal box; d = sliding door.

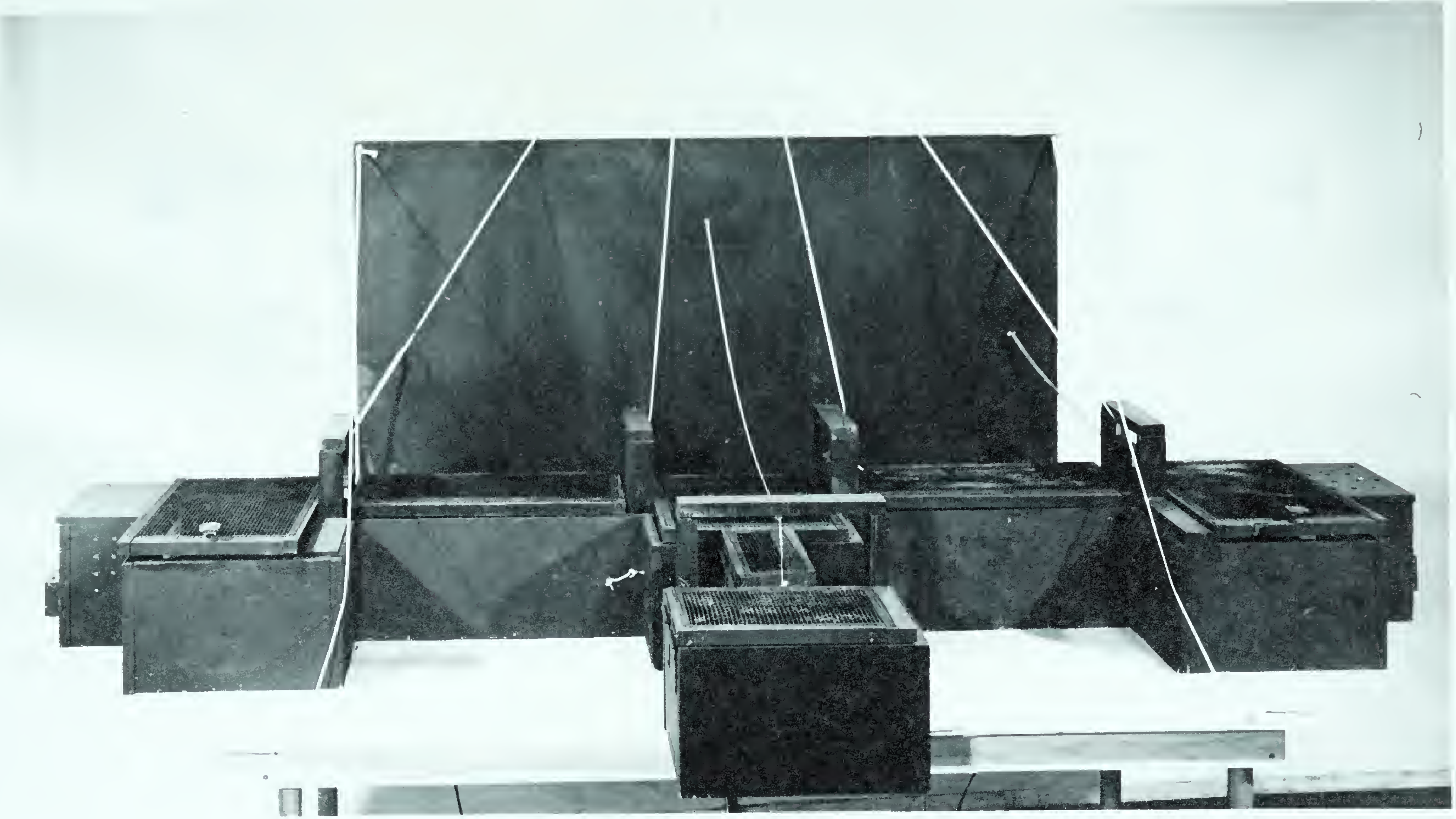

Fig. 3. The T-maze showing the shield behind which the *E* operated the guillotine doors.

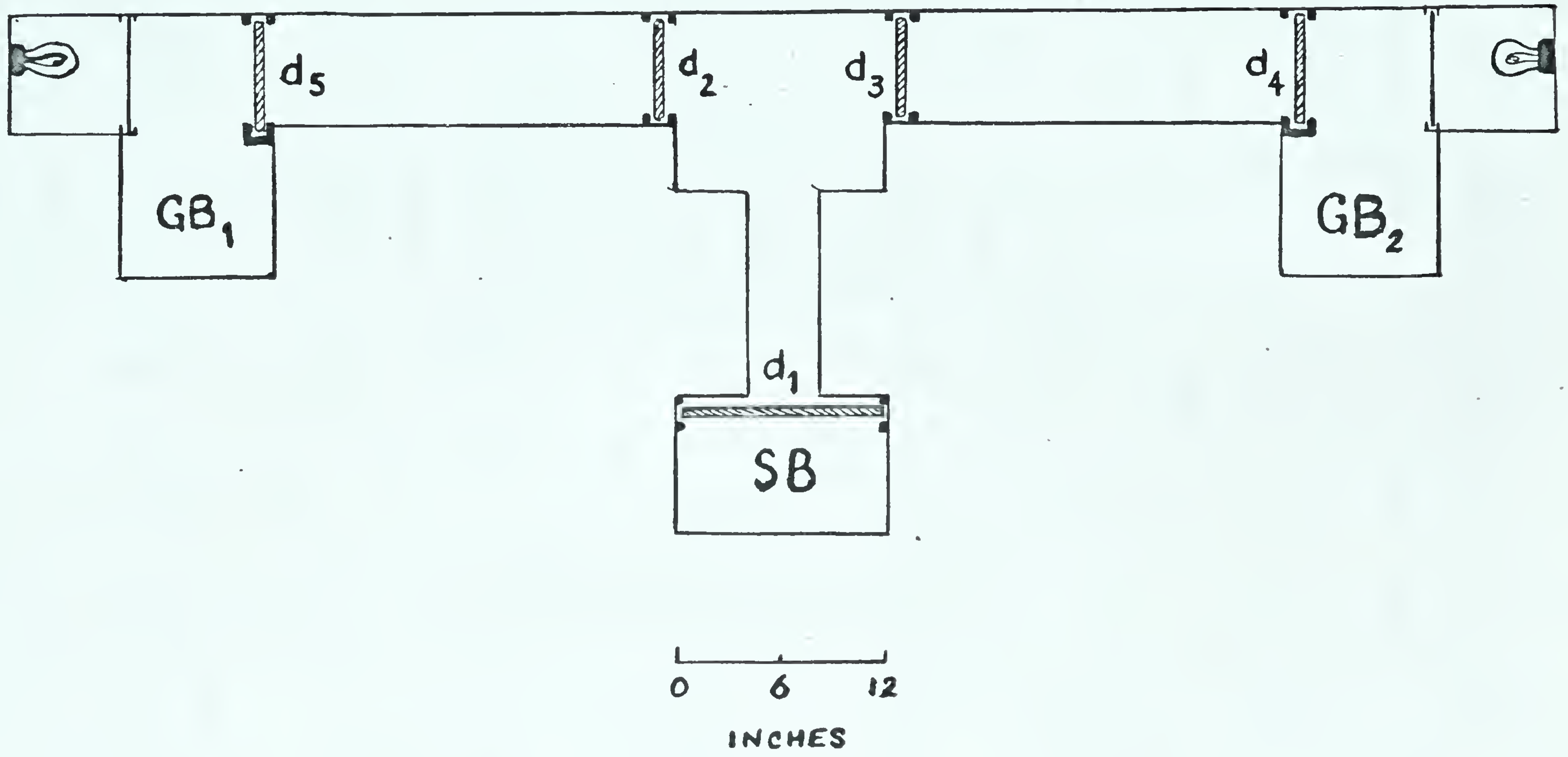

Fig. 4. Scale drawing of the T-maze. SB = start box; GB = goal box; d = sliding doors.

assigned to each of the treatments. There were four training groups (T): C, the correction method group; R-C, the rerun correction method group; NC, the noncorrection method group; and R-NC, the rerun noncorrection method group. Each group had eight Ss which were further randomly assigned to one of the two mazes (D)--parallel alley or T. The four Ss in each of these groups were then randomly assigned to either the spatial position problem (A_1) or the discrimination problem (A_2). As a result, two Ss were in each condition and one of the two was trained in the evening and the other in the morning. All Ss were then tested for preference in the pretraining period. That is, Ss in the position group were given ten free nonreinforced trials to assess their preference for the right or left goal box and similarly, the Ss in the discrimination group were given ten free trials to show their preference for the goal box with or without the added light. Half the Ss were then assigned to the condition of training to their preference and half to their nonpreference.

Each S was given five trials per day and the criterion of learning was set at two consecutive errorless days of five trials each for acquisition of the learned response. Extinction for all Ss was carried out using NC for eight days (40 trials).

In addition, VTEs (vicarious trials and errors) were recorded with the intention of assessing the correlation between VTEs and correct and wrong responses in the experimental design. One VTE was counted when a rat looked up one alley and this was followed by a look at (or final taking-off-toward) the other door (Tolman, 1951).

Terminology

A trial was defined in terms of group membership. That is, a trial for Ss in the C and R-NC groups was completed on performance of the correct response and subsequent reinforcement. A trial for Ss in NC was completed upon making either a correct or wrong response. Subjects in R-C completed a trial only upon making a run from start box to correct goal box (no wrong responses). An error was defined as a wrong turn (wrong response) by the entry of the whole body of the S exclusive of tail into the incorrect alley. A correct response could be defined in two ways: (a) when a S's first choice results in the attainment of the reward, and (b) when a S attains reinforcement regardless of the number of choices made prior to this. In the analyses reported in the results section, definition (b) is used although an analysis using definition (a) is considered in the general discussion section. The termination of a response by the E (the removal of the animal from the apparatus) constituted a run. A comparison of the dependent variables and training methods is shown in Table 1.

Procedure

Pretraining and experimental training were the same for the three replications, each involving 32 Ss.

Pretraining. The Ss were placed on a 23-hour water deprivation schedule five days before pretraining commenced and were maintained on this schedule throughout the experiment. During this period the

Table 1

A Scoring Comparison of Dependent Variables and Training Methods Based on One Trial.

Training Methods	Dependent Variables			
	Trials	Errors	Correct Responses	Runs
C	1	0, 1 or x[a]	1	1
R-C	1	0, 1 or x	1 or x	1 or x
NC	1	0 or 1	0 or 1	1
R-NC	1	0, 1 or x	1	1 or x

[a] $x > 1$

*S*s were briefly handled each day by the *E* and then watered for an hour. Sixteen *S*s were placed on morning training and the remainder on evening training. Food was always available in the living cages.

On the sixth day, all *S*s, four at a time, were placed together in the parallel alley or T-maze according to assignment. Each group of four *S*s involved the four training methods to acquire one of the two problems in a particular apparatus design. Free exploration in the apparatus with all guillotine doors open was allowed for ten

minutes followed by ten minute periods in the living cages for a period of one hour (three ten minute sessions in the maze alternately with three ten minute sessions in individual living cage). During the final ten minute period, the goal box doors were closed, the drinking cups were filled with water, and each S was individually watered in each goal box for one minute.

On the seventh day each S in the group of Ss to be run alternately, was given preference trials. In the case of the spatial problem, Ss were given ten free trials to chose the right or left goal box. (A trial, here, was defined as the unreinforced choice of either the right or left goal box.) The intertrial interval varied due to the slowness of certain Ss. Each S was tested individually in the same order in which it would receive its training. That is, the Ss to be trained on the spatial position problem in the parallel alley maze, were tested individually in the order in which they would receive their training--C, R-NC, R-C, NC. Similarly, each S in the discrimination condition was given ten trials to establish a preference for the goal box with added or no added illumination. The position of the added light was varied according to the Gellerman (1933) series RRLLRLLRRL.

Under each condition half the Ss were to be trained to their preference and half to their nonpreference. The decision to train a S to its preference or nonpreference was decided by the flip of a coin. If a S showed no preference in the ten trials (50-50) a coin was tossed to establish its preference (seven Ss out of 96 or 7.3% showed no preference). The criterion of preference was six or more responses to the right or left goal box, or to the lighted or unlighted goal box, for Ss in A_1 and A_2 respectively.

Acquisition. Training commenced on the day after pretraining and consisted of reinforcing either the preferred or nonpreferred goal box by two drops of water in a water cup. A S was placed in the start box with d_1 closed and all other guillotine doors open. After 15 seconds, d_1 was opened. When a correct choice was made the appropriate door was closed. If an error was committed, the door was closed behind the Ss in the NC and R-NC groups. Upon making an incorrect response, Ss trained by NC and R-NC were retained in the goal box for 15 seconds. The Ss of the NC group were returned to their living cages 15 seconds after either a correct or incorrect response. The Ss of the R-NC group were returned to the start box for the rerun. Subjects trained by C or R-C were allowed to return to the choice point after having made a wrong turn. The C group Ss were returned to their living cages upon making a correct response. Those Ss of the R-C groups were returned to the start box for the rerun and returned to their living cages upon making an errorless run.

Training was carried out individually in groups of four Ss--C (correction), R-NC (rerun noncorrection), R-C (rerun correction), and NC (noncorrection), with Ss to learn the position habit (A_1) in the parallel alley followed by Ss in the T-maze. Then another four Ss were individually trained in the same order on the discrimination problem (A_2)--four Ss in the parallel alley followed by four in the T-maze. Five trials per S were run each day with the intertrial interval kept proportional over days. That is, the intertrial interval was longest on the first day becoming progressively shorter as learning progressed with a minimum of five minutes.

The Ss in group A_1 (position habit) were given no additional cue of goal box differences (no added light in the positive box). The Ss were trained according to their preference or nonpreference of a goal box position. Subjects in A_2 condition were trained according to their preference or nonpreference of an added light in the positive goal box. The added light was on in the goal boxes according to the series--RLLRR on odd training days and RLRLL on even days. If, for example, a S was being trained to a preference or nonpreference of added light, the reward on the first trial of day one was on the right, otherwise, the reward was on the left. The running time (seconds) was recorded from the opening of d_1 to a S making a choice (right or wrong) for all Ss under all conditions.

Extinction. After each S met the criterion of two consecutive errorless days, extinction commenced in all conditions. The extinction method was NC for all Ss regardless of their original groups. There was no reward and each S ran five trials per day for eight days (40 trials). The running time from opening d_1 to a S making a choice, right or wrong was recorded for all Ss.

Results

In order to facilitate the coherence of this presentation of the results, the data will be presented in terms of the following dependent variables under the major headings of acquisition and extinction: trials, errors, correct responses, and runs. The questions posed in the introduction will be considered in the discussion. In addition, all interactions are shown graphically in the appendix.

Acquisition. The running speeds from start box to making a choice during acquisition showed no significant differences and no further consideration of these will be made here. The means and standard deviations of the four dependent variables, trials, errors, correct responses, and runs during acquisition of a position habit (A_1) and discrimination learning (A_2) are given in Table 2. The analyses of variance were computed using orthogonal comparisons (α = .05 one-tailed $\underline{F}$ test). The data for all conditions were subjected to $\underline{F}_{max.}$ test (α = .05) with no indication of heterogeneity.

Trials. In terms of the definitions used here, a trial was equivalent to a correct response (reinforcement) and a run in C; a run in NC; and a correct response in R-NC (Table 2). The acquisition of the position habit required significantly fewer trials to reach the criterion of learning than the brightness discrimination task ($p < .001$) (Table 3). The only other significant main effect found was that training to preference was more

efficient than training to nonpreference ($p < .01$). A test of the D x T interaction showed a significant difference between C and R-C only ($p < .05$).

Table 2

Means and Standard Deviations for Trials, Errors, Correct Responses, and Runs to Criterion for Training Methods in Acquisition of a Position Response (A_1) and Brightness Discrimination (A_2)

Training Methods	A_1 or A_2	Trials		Errors		Correct Responses		Runs	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
C	A_1	19.55	14.98	11.75	13.53	19.55	14.98	19.55	14.98
	A_2	47.05	20.61	29.60	14.98	47.05	20.61	47.05	20.61
R-C	A_1	18.30	12.49	13.25	10.17	28.85	18.37	28.85	18.37
	A_2	38.75	13.84	36.10	9.09	70.85	22.52	70.85	22.52
NC	A_1	25.00	7.83	10.75	4.11	14.25	3.85	25.00	7.83
	A_2	36.67	16.80	16.85	7.28	19.60	10.55	36.67	16.80
R-NC	A_1	16.67	3.91	9.15	4.24	16.67	3.91	25.83	6.99
	A_2	35.45	22.20	20.90	13.81	35.50	22.20	56.40	37.04

Table 3

Analysis of Variance of the Trials to Criterion in Acquisition

	df	MS	F
Apparatus (D)	1	176.04	------
Problem (A)	1	9204.17	48.96***
Training Methods (T)	3	284.03	1.41
Preference (P)	1	1350.00	7.18**
D x A	1	-------	------
D x T	3	413.19	2.20
D x P	1	37.50	------
A x T	3	189.24	1.01
A x P	1	234.37	1.25
T x P	3	46.53	------
D x A x T	3	54.86	------
D x A x P	1	234.37	1.25
D x P x T	3	84.03	------
A x P x T	3	115.60	------
D x A x T x P	3	240.63	1.28
Treatment	31	500.67	2.66***
Replications	2	1932.67	
Error	62	187.99	

**$p < .01$

***$p < .001$

Errors. The analysis of variance of the error data demonstrated that the acquisition of a position habit differed significantly from the discrimination task ($p < .001$) (Table 4). The apparatus design was not found to be a significant factor in terms of errors but preference was found significant beyond the .05 level. The interaction of tasks and training methods (A x T) and the three-way interaction of apparatus design by problems by training methods (D x A x T) showed significance beyond the .05 level. An examination of the orthogonal comparisons showed a significant difference ($p < .001$) between combined correction methods, C_c, where $C_c = C + R\text{-}C$, and the combined noncorrection methods, $NC_c = NC + R\text{-}NC$. That is, the C method plus R-C, was not as efficient in training Ss as was the NC method including R-NC. This was particularly true in learning the discrimination problem in both parallel alley and T-mazes. This finding was further confirmed in the problem by training method (A x T) and apparatus by problem training method (D x A x T) interactions ($p < .01$). In A x T and D x A x T, the NC group showed faster learning of the discrimination task (A_2), whereas R-NC was more efficient in learning the position habit (A_1).

Correct responses--reinforcements. The analysis of variance of correct responses as reinforcements, showed all main effects except apparatus design significant ($p < .001$) (Table 5). Examination of the orthogonal comparisons in the main effects showed NC_c to be more efficient than C_c with C significantly more efficient

Table 4

Analysis of Variance of Errors to Criterion in Acquisition.

	df	MS	F
Apparatus (D)	1	130.67	1.48
Problems (A)	1	4477.13	50.77***
Training Methods (T)	3	614.75	6.97***
Preference (P)	1	601.04	6.92*
D x A	1	35.04	------
D x T	3	133.36	1.51
D x P	1	63.38	------
A x T	3	317.79	3.60*
A x P	1	24.00	------
P x T	3	43.37	------
D x A x T	3	380.29	4.31**
D x A x P	1	253.50	2.87
D x P x T	3	51.07	------
A x P x T	3	73.44	------
D x A x P x T	3	159.58	1.81
Treatments	31	352.08	3.99***
Replications	2	1007.87	
Error	62	88.18	

*$p < .05$
**$p < .01$
***$p < .001$

Table 5

Analysis of Variance of Correct Responses to Criterion in Acquisition

	df	MS	F
Apparatus (D)	1	283.59	1.87
Problems (A)	1	12903.84	85.20***
Training Methods (T)	3	4547.35	30.02***
Preference (P)	1	2044.26	13.50***
D x A	1	8.76	------
D x T	3	523.17	3.45*
D x P	1	36.26	------
A x T	3	1447.59	9.56***
A x P	1	15.84	------
P x T	3	85.39	------
D x A x T	3	1366.87	9.02***
D x A x P	1	536.76	3.54
D x P x T	3	87.28	------
A x T x P	3	223.37	1.47
D x A x T x P	3	79.62	------
Treatments	31	1319.73	8.71***
Replications	2	2519.88	
Error	62	151.46	

*$p < .05$

***$p < .001$

than R-C ($p < .001$). In addition, NC was found to be significantly superior to R-NC in all instances. The task-training method interaction (A x T) demonstrated that NC_c was superior in the learning of both problems and noticeably superior in learning the brightness discrimination task ($p < .001$). Both problems were learned by all Ss in the noncorrection and correction groups. However, there were fewer reinforcements required by the noncorrection methods to reach the criterion of learning than by the correction methods. Little difference between training methods occurred in learning the position habit in the parallel alley and T-mazes. However, the D x A x T interaction demonstrated differences between C_c and NC_c in the parallel alley in learning the discrimination task ($p < .001$). This same interaction demonstrated marked differences between R-C and NC and little difference between C and R-NC in the T-maze in learning the discrimination. In addition, the apparatus design by training method (D x T) interaction showed a significant difference between C and R-C ($p < .01$) with R-C requiring the most reinforcements to reach the criterion of learning. NC was shown to be the superior method in terms of reinforcements.

Runs. The analysis of variance demonstrated that the discrimination task required more runs to reach the criterion of learning than the position habit (Table 6). As for the previous three dependent variables, no significant differences between the parallel alley and T-maze designs were obtained.

Table 6

Analysis of Variance of Runs to Criterion in Acquisition

	df	MS	F
Apparatus (D)	1	294.00	------
Problems (A)	1	19410.07	62.39***
Training Methods (T)	3	1525.99	4.90**
Preference (P)	1	2562.67	8.24**
D x A	1	60.17	------
D x T	3	566.44	1.82
D x P	1	240.67	------
A x T	3	942.11	3.03*
A x P	1	228.17	------
P x T	3	44.97	------
D x A x T	3	148.18	------
D x A x P	1	450.67	1.45
D x P x T	3	344.80	1.11
A x T x P	3	379.25	1.22
D x A x T x P	3	409.52	1.32
Treatment	31	1171.94	3.77***
Replications	2	3551.85	
Error	62	311.11	

*$p < .05$
**$p < .01$
***$p < .001$

However, the other three main effects reached significance ($p < .01$). An examination of the orthogonal comparisons showed that C was significantly superior to R-C in terms of runs ($p < .01$). The A x T (problems by training methods) interaction showed that the NC_c methods were overall superior to C_c in terms of runs. For learning the position habit, C was the superior method while NC was more efficient in learning the discrimination task.

Extinction. The NC method was used in the extinction of the acquired habits. This made the error score and the correct responses together, equivalent to the number of runs or trials (40 runs or trials). The error scores are presented in Table 7 and no significant differences were found ($Fs < 1$).

The running speeds from start box to making a choice were recorded on all trials. The mean reciprocal values of the time in seconds were plotted against blocks of five trials (days) (Fig. 5 and Fig. 6). Several more graphs can be found in the appendix (Figs. 7, 8, and 9). In Fig. 5, a comparison of the running speeds for Ss and C_c and NC_c in the extinction of a position habit and brightness discrimination in the T-maze is made. By the last day there was little difference between the running speeds of the different groups although the Ss of C_c were extinguishing the acquired position habit faster than the other groups. The extinction running times in the parallel alley maze (Fig. 6) show the Ss in NC_c groups for both tasks extinguishing the acquired habit more quickly than those in the C_c groups. There were no significant differences between groups.

Table 7

Means and Standard Deviations of Error Scores in Extinction[a]

Method	Problem	Mean	SD
C	A_1	25.25	5.36
	A_2	22.60	4.51
R-C	A_1	24.00	4.61
	A_2	23.00	4.81
NC	A_1	26.67	3.58
	A_2	23.60	4.17
R-NC	A_1	24.80	2.92
	A_2	22.75	3.66

[a] 40 NC trials at 5 trials/day

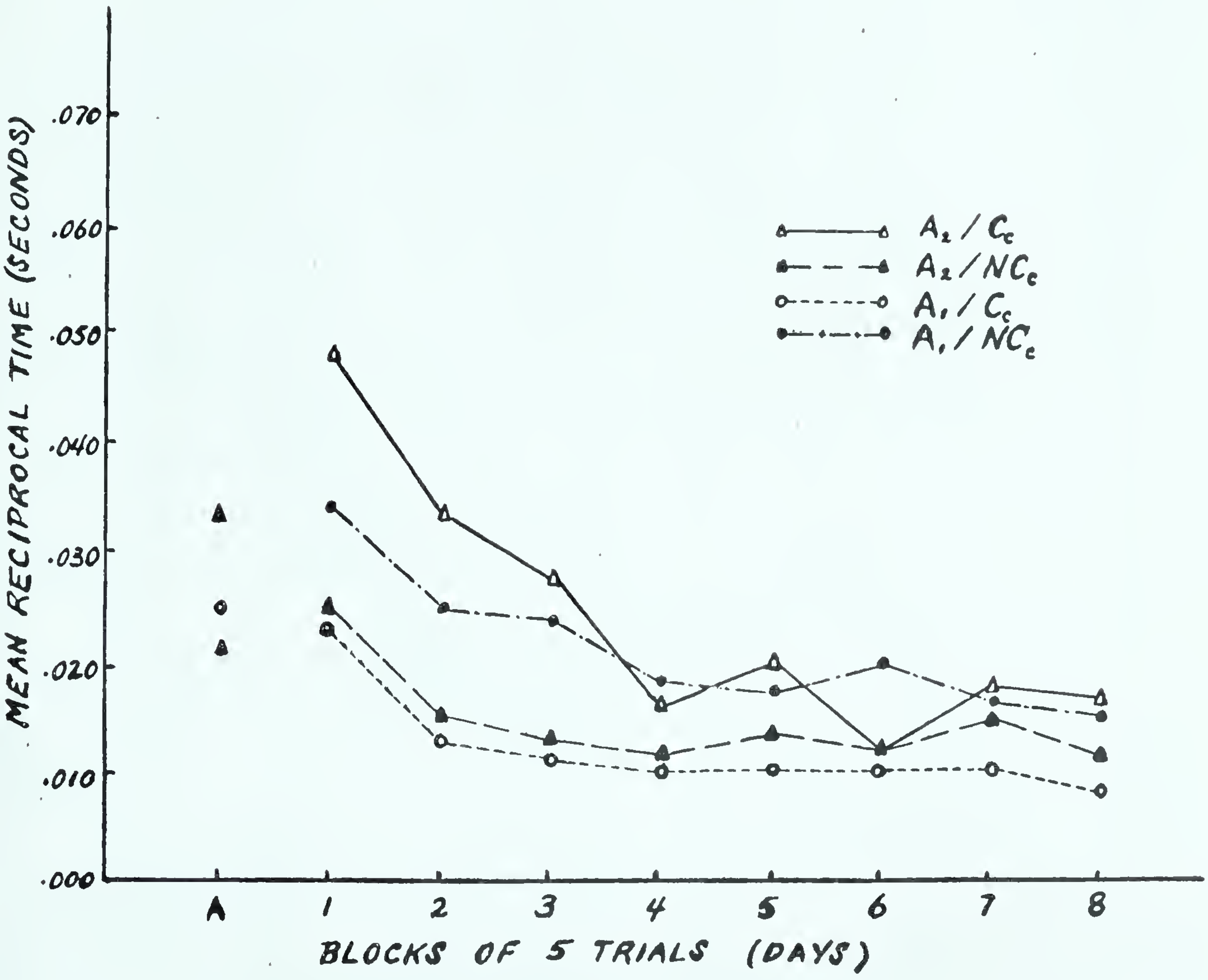

Fig. 5. Combined correction (C_c) and combined noncorrection (NC_c) methods in extinction of a position habit (A_1) and discrimination problem (A_2) in the T-maze.

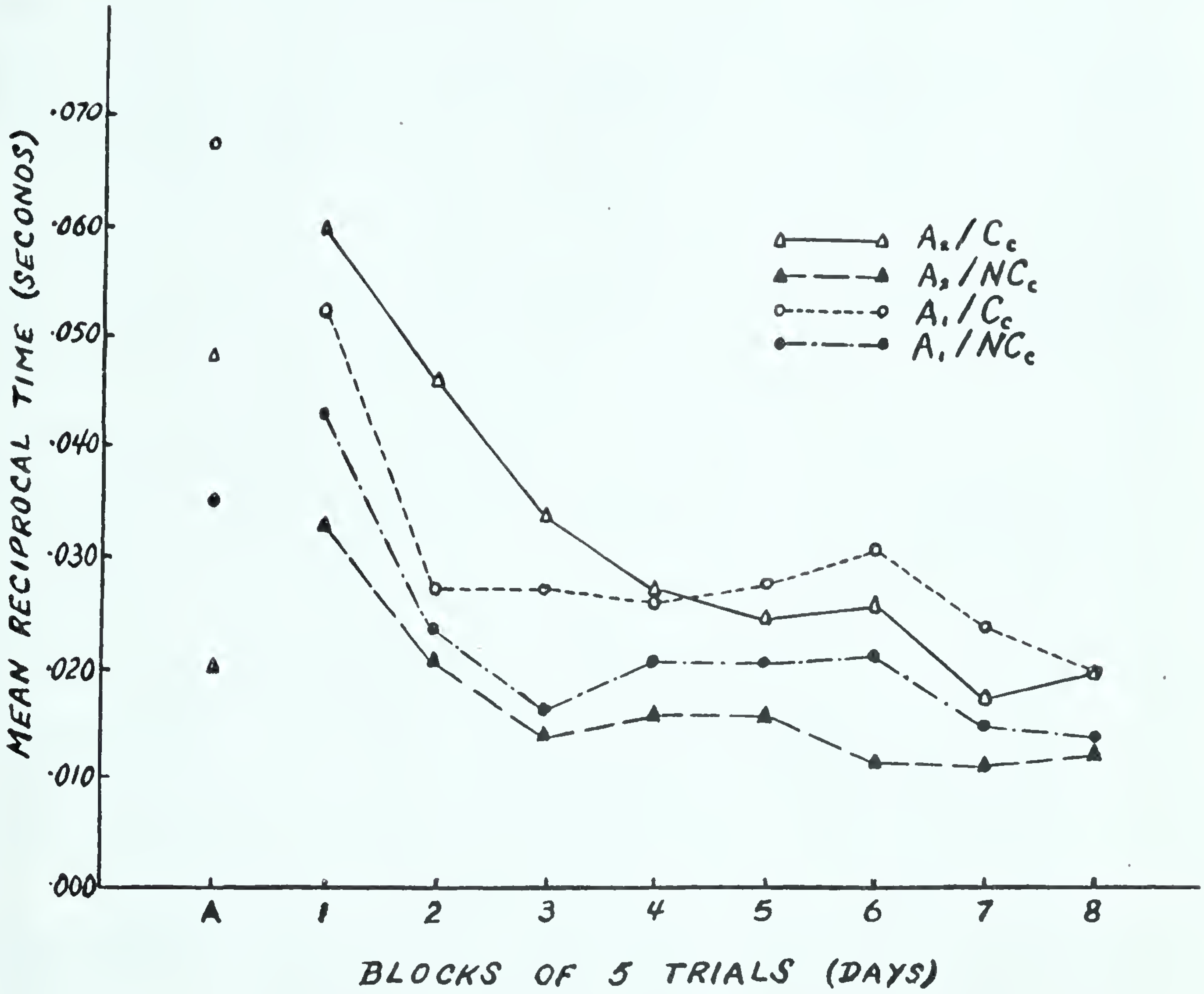

Fig. 6. Combined correction (C_c) and combined noncorrection (NC_c) methods in extinction of a position habit (A_1) and discrimination problem (A_2) in the parallel alley maze.

VTEs. Although not considered a formal dependent variable, in terms of design, the behavior of the rats at the choice point was recorded in number of VTEs. In Table 8, the correlations of VTEs with errors and correction responses in acquisition is shown Two significant correlations ($p < .05$), the correlations between errors and VTEs in the parallel alley maze using the discrimination task, were found. The correlations of correct responses with VTEs under NC ($n = 6$ per cell) were all significant ($p < .05$). Under preference factors, the correlation between VTEs and errors ($r = .62$ with $n = 12$) was the only significant result. Nonpreferred training in the T-maze with the position task showed significant correlations for both errors and correct responses. Additional correlations, which are not central to the problems of this experiment, may be found in the appendices (Tables 2 and 3).

In extinction, the correlations between errors and VTEs were calculated and only one significant r-value ($r = .93$) was obtained. These were obtained by the P-NC group learning the position task in the T-maze.

Table 8

Correlations between Errors, Correct Responses and VTEs for Training and Preference Factors under Position Habit and Discrimination Acquisition in the Parallel Alley and T-mazes

Problem	Apparatus	Training Methods^1								Preference^2			
		C		R-C		NC		R-NC		Preferred		Non-Preference	
		E	C.R.	E	C.R.	E	C.R.	E	C.R.	E	C.R.	E	C.R.
Position Response A_1	Parallel Alley	.31	.39	-.03	.09	.28	*.80	.16	-.10	.43	.48	.07	.15
	T	.27	.62	.61	.24	.28	*.83	.59	.53	.20	.12	*.51	*.93
Discrimination A_2	Parallel Alley	.42	.18	-.20	.21	*.84	*.72	*.93	*.94	*.62	.45	.01	.01
	T	.08	-.11	.38	.45	.54	*.79	.13	.00	-.21	-.14	.40	.33

Note. E = error correlations; C.R. = correct response correlations.

$*p < .05$ ${}^1n = 6$ ${}^2n = 12$

Discussion

The purpose of this paper, as outlined in the introduction, was to investigate and evaluate the relative efficiency of the four training methods, C, R-C, NC, and R-NC, under different conditions. This discussion will try to answer the questions posed in terms of the experimental results.

A significant difference between the training methods was found in all dependent variables except trials with NC_c generally superior to C_c methods. Even under trials, a trend toward fewer learning trials using R-NC can be seen in Table 2. This supports the findings of Kalish (1946) as does the error data for A_1. In his report, Kalish (1946) stated there was no evidence of the Ss of the correction group learning the problem. In contrast to this, all the Ss in the present study reached the criterion of learning.

Muenzinger and Powloski (1951) found C significantly better than R-NC in a light/dark discrimination situation using a T-maze. In the brightness discrimination task in this study, a similar trend was found in the T-maze situation in terms of mean error scores. However, these results were not significant. In contrast, the mean error scores in the parallel alley maze for the brightness discrimination task show significant differences between C/R-C and R-NC/NC with the latter two methods superior. These findings support the suggestion made by Muenzinger and Powloski (1951) that different learning records might be obtained using a parallel alley maze. They reasoned that C might become less effective in the parallel alley

maze because the Ss in C would have to turn around the choice point and face the left/right choice after an error, whereas in the T-maze, they could keep moving in a straight line past the choice point to the rewarded arm.

The results reported by Towart and Boe (1965), in terms of trials and errors, showed no significant difference between C and R-NC in learning a position response in a parallel alley maze. These findings were supported by this study (Table 2; Appendices, Fig. 1a and 2a). The rerun noncorrection (R-NC) procedure appeared to be more efficient than the correction methods in the acquisition of a position in a parallel alley maze in terms of all dependent variables except runs and NC more efficient except in terms of trials and runs. It is possible that the selection of a training method could be left to the discretion of the E when using the parallel alley in a similar situation as the methods show little variation. However, it is likely that one of the noncorrection procedures would provide faster learning.

The superiority of NC over C in terms of trials, errors, and correct responses in a T-maze for both tasks--the position response and brightness discrimination, lend support to the work of Besch et al (1963), Kalish (1946), Parducci and Polt (1958), and Seward (1943)

Within the terms defined by this study, the noncorrection methods produced more efficient acquisition of both tasks in the two maze designs. Although the differences between training methods in learning a position response in both mazes are small, large differences occur in making a brightness discrimination. In view of this, the training method selected in a brightness discrimination situation should be

carefully considered in terms of the dependent variable to be used and the apparatus design.

A possible explanation for the efficiency of the noncorrection procedures involves the concept of behavior sequences (Kalish, 1946). The S learning in a maze by one of the correction methods is faced with two alternatives: (a) to take the long path--to make one or more wrong responses followed by the correct response, or (b) to take the short path--to make the correct response. In this behavior sequence, a S could receive positive reinforcement of the wrong response by choosing the long path. In the noncorrection methods, the S makes one of two different responses--an error or a correct choice. Thus, there are two distinct behavior sequences in noncorrection with no reinforcement of the wrong choice. This separation of correct and incorrect responses may be an important factor in learning situations (Hill, Cotton, & Clayton, 1962).

The apparatus design appeared to have little influence upon learning in terms of trials and runs. However, design did appear to have some effect upon acquisition according to error and correct response scores. According to the results of this investigation, the use of either apparatus design in a similar position response problem should have little influence on the training procedure selected. However, in the case of the discrimination task, the parallel alley maze results showed the C/R-C and NC/R-NC methods differed slightly with a significant difference between the correction and noncorrection methods. In contrast, the T-maze results for discrimination indicated little disparity between C and R-NC with a

significant difference between R-C and NC. In the case of discrimination problems, the selection of NC should prove more efficient in either apparatus design.

The acquisition of a position habit was found to be significantly different from learning a brightness discrimination. In addition, the interaction of tasks and training methods was found in terms of errors, correct responses and runs. Little dissimilarity between training methods was demonstrated in the learning of a position response but marked slower learning was found when C or R-C was used in the discrimination task. The results of this experiment lend support to the findings of McKelvey (1956) who found NC more effective in learning a brightness discrimination using a T-maze. Moreover, support was given to studies using different discrimination tasks which found NC to be the better procedure (Besch et al., 1963; Wischner, 1947; Wischner, Fowler, & Kushnick, 1963).

Direct comparison of the number of reinforcements received by the Ss was only possible between C and R-NC. In this experiment, Ss in R-NC showed better performance except in the T-maze discrimination task where the C group had a slight (nonsignificant) advantage. Since correct responses were defined as reinforcements, the overall picture shows the NC method, in which the Ss received the least number of reinforcements, to be superior in both problems. These findings corroborate those of Hill et al (1962) in which they showed that even though NC Ss received half as many reinforcements as those in the C group, acquisition was superior by NC. They

suggested that these findings gave further support to the improved efficiency of learning a discrimination with a combination of rewarded and nonrewarded trials than with all trials rewarded. North (1950a; 1950b) also showed that NC learned the given task with fewer reinforcements than C even though he could not demonstrate any significant differences between C and NC. The present experimental findings further imply that the nonreward of incorrect responses is an important consideration in similar learning situations.

By defining a correct response as a _S_'s first choice which terminates in the attainment of the reward, nonsignificant results for all main effects and interactions were found in the present experiment. (The analysis of variance results can be examined in the appendix.) With correct responses recorded as first choices, the actual number of reinforcements a _S_ obtains is ignored. In this investigation, the number of reinforcements and their influence in learning is of crucial importance. This kind of analysis points out the obvious importance of definitional considerations not only in the interpretation of results, but in the actual collection of data.

When Seward (1943) found NC superior to C after forced trials to each side of the maze, he speculated on the influence of preference bias. He suggested that the lack of difference between C and NC, found by Hull and Spence (1938), might have been due to training _Ss_ to their preferred direction. In 1956, McKelvey gave the rats in pretraining, two free-choice runs followed by two forced runs to counterbalance position habits. In interpretation

of his results, he suggested that NC tended to reduce position habits more effectively than C. In the present study, ten preference trials were given to all Ss with half the Ss trained to their preference and the remainder to their nonpreference. The results showed a significant difference between training to preference and training to nonpreference which agrees with past findings (Brogden, 1951). However, even though a S will learn faster when trained to its preference, this factor did not influence the training methods used under the different conditions. Therefore within the conditions of the present experiment, it would appear that preference facilitates learning but has negligible influence on training procedures and tasks.

Extinction scores showed little difference between training methods on either of the tasks. This implies that the extinction process was little influenced by training methods in the experimental conditions. The running speeds showed that extinction of the original learned tasks was occurring as all Ss were running slower by the last day. The running speed differences by the eighth day were nonsignificant between the training groups. The comparison of training methods in acquisition followed by extinction has not been undertaken before.

The correlational analyses of VTEs in the present investigation can be interpreted as the expression of a specific tendency (Tolman & Ritchie, 1943), e.g., the positive correlation between correct responses and VTEs across all conditions when using the NC method in acquisition.

This suggests that the relationship between reinforcements and VTEs in acquisition may have influenced learning by NC. The correlations found between errors and VTEs in extinction were not significant.

Summary and Conclusions

An experiment was performed to determine the relative merits of correction, rerun correction, noncorrection, and rerun noncorrection training methods in a parallel alley maze and T-maze using the acquisition of a position habit and the determination of a brightness discrimination as problems. In addition, preference versus non-preference training was considered.

The results support the following conclusions:

1. There was a significant difference between training methods on all defined dependent variables except trials. The NC_c methods were found to be more efficient under all conditions.

2. Apparatus design interacted significantly with tasks and training procedures in terms of error and correct response scores. The correction procedures were found to be less efficient than the noncorrection procedures in the parallel alley maze. In the T-maze and the discrimination problem, little difference was found between C and R-NC, but a significant difference was found between R-C and NC. It would therefore seem that one of the noncorrection procedures should be most efficient in both mazes--particularly in the discrimination task.

3. There was a significant difference between learning a position response and determining a brightness discrimination with the latter task requiring a longer time to learn. There was little difference found between training methods in learning a position response. The brightness discrimination task differentiated

the training methods more clearly and NC was found to be the most efficient procedure in the T-maze.

4. Correct responses were equivalent to reinforcements in all methods. Despite the fact that it received the least number of reinforcements, NC was shown to be the superior method on both problems.

5. Training to preference facilitated learning but did not influence training methods.

6. There were no significant findings in extinction. All Ss were extinguishing the learned habit by the eighth day as was shown by the slower running speeds.

7. The positive correlation between VTEs and correct responses in NC under all conditions suggest that a relationship existed between the number of reinforcements and VTEs and that this relationship may have facilitated learning.

The use of rigorously defined training methods and dependent variables has made available a basis on which to compare future studies. In addition, studies which reached different conclusions on similar problems and utilized different training methods, could be reconsidered in the light of these findings. The use of one training method (NC) in the extinction of the acquired habits, did not show significant differences between the training methods used in acquisition. It would appear that the noncorrection methods are to be preferred in most maze learning situations.

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APPENDICES

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INTERACTIONS

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EXTINCTION RUNNING TIME

Fig. 7 - Fig. 9

ANALYSIS OF VARIANCE OF FIRST CHOICES IN ACQUISITION

Table 1

CORRELATIONS BETWEEN ERRORS, CORRECT RESPONSES AND VTEs IN ACQUISITION

Table 2

CORRELATIONS BETWEEN ERRORS AND VTEs IN EXTINCTION

Table 3

APPENDIX 1

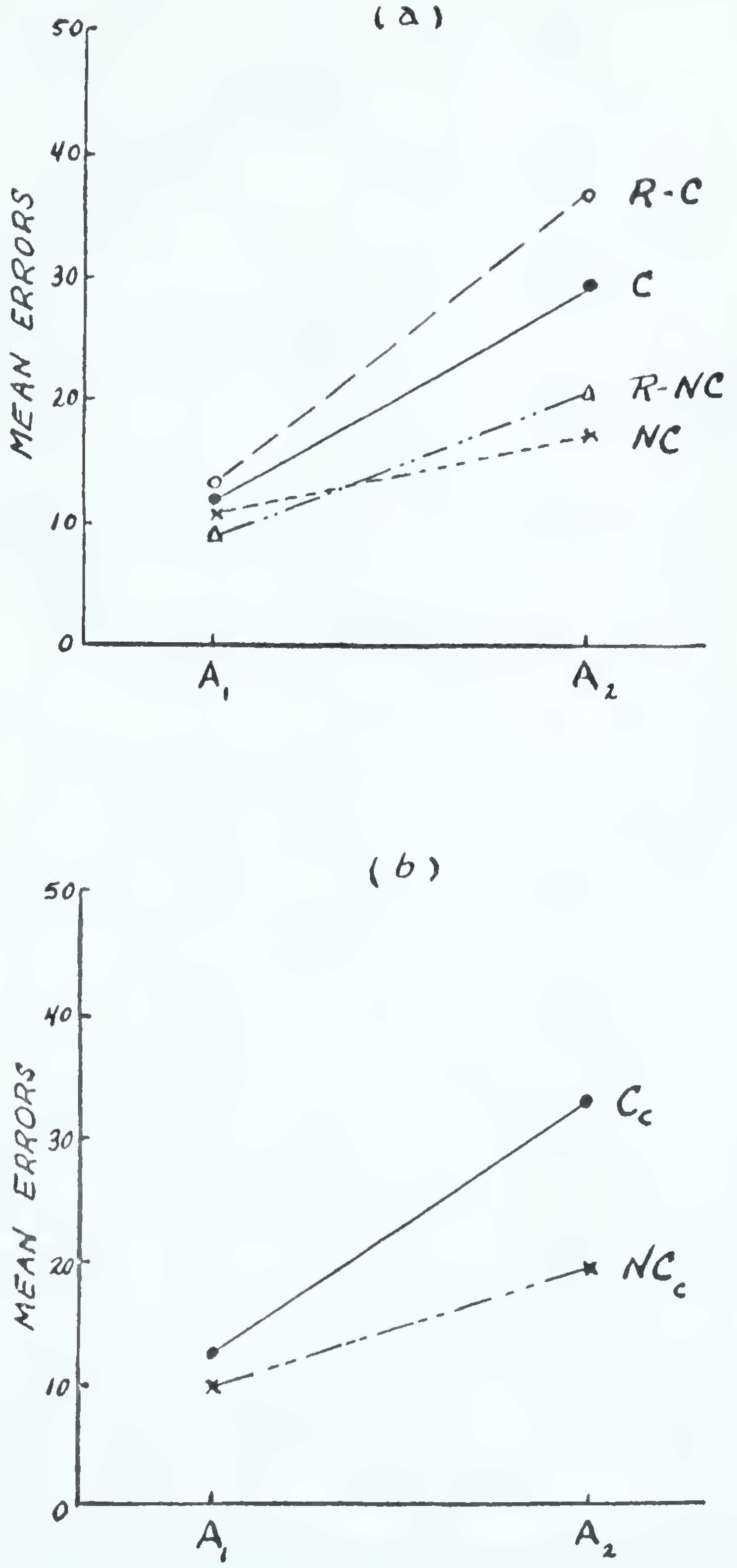

Fig. 1. The A x T interaction in terms of mean error scores. A_1 = position problem; A_2 = discrimination task.

(a) The training methods are considered separately.
(b) The training methods are combined.

APPENDIX C

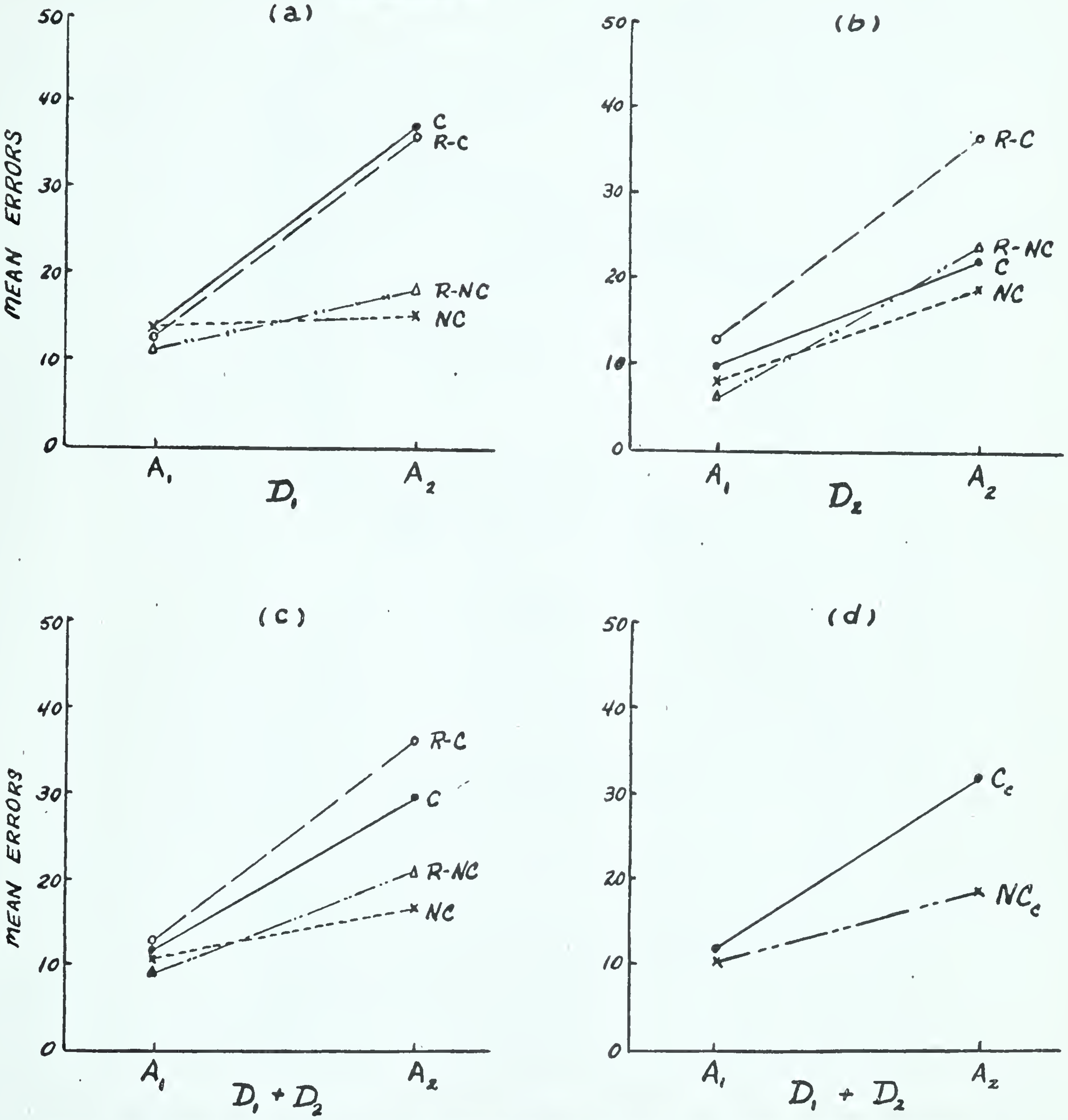

Fig. 2. The D x A x T interaction in terms of mean error scores. A_1 = position problem; A_2 = discrimination task; D_1 = parallel alley maze; D_2 = T-maze. (a) A x T over D_1; (b) A x T over D_2; (c) A x T over D_1 + D_2; and (d) A x T with combined correction and noncorrection methods.

APPENDIX 3

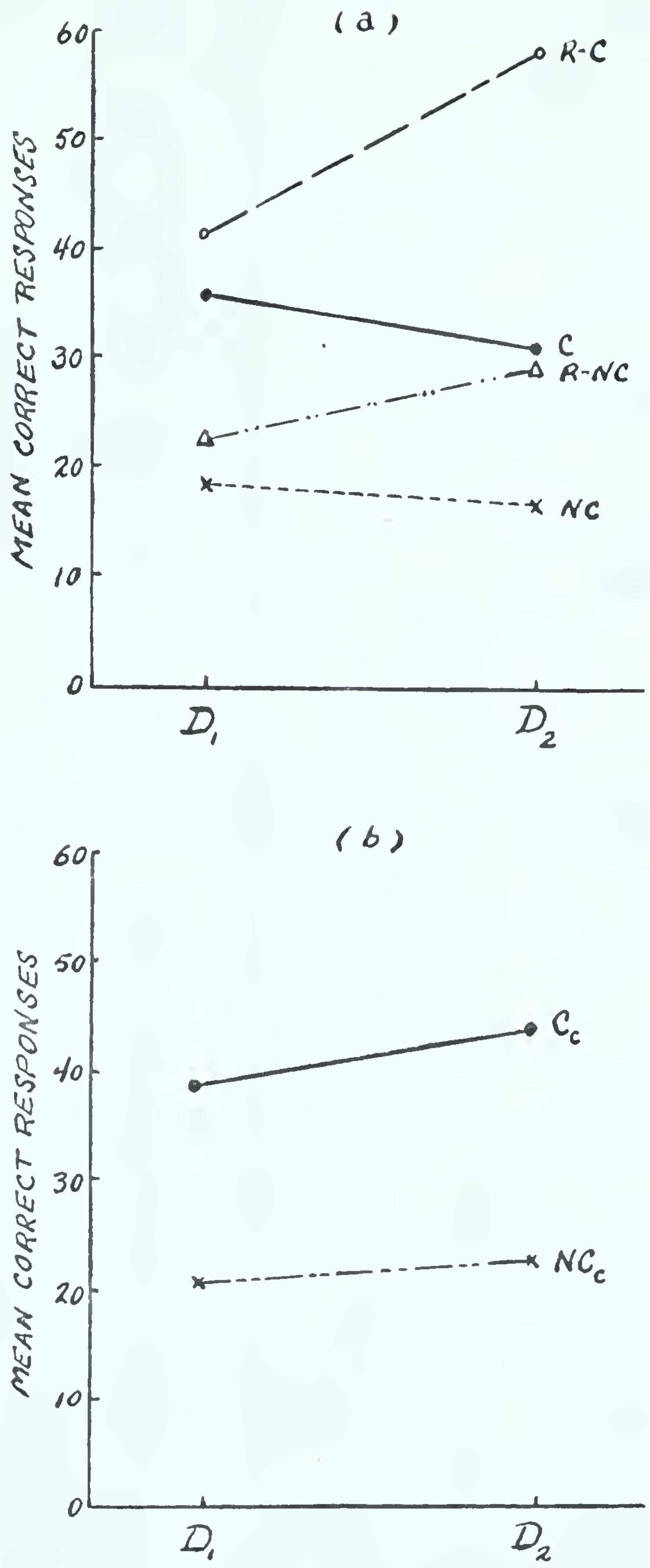

Fig. 3. The D x T interaction in terms of correct responses. D_1 = parallel alley maze; D_2 = T-maze.

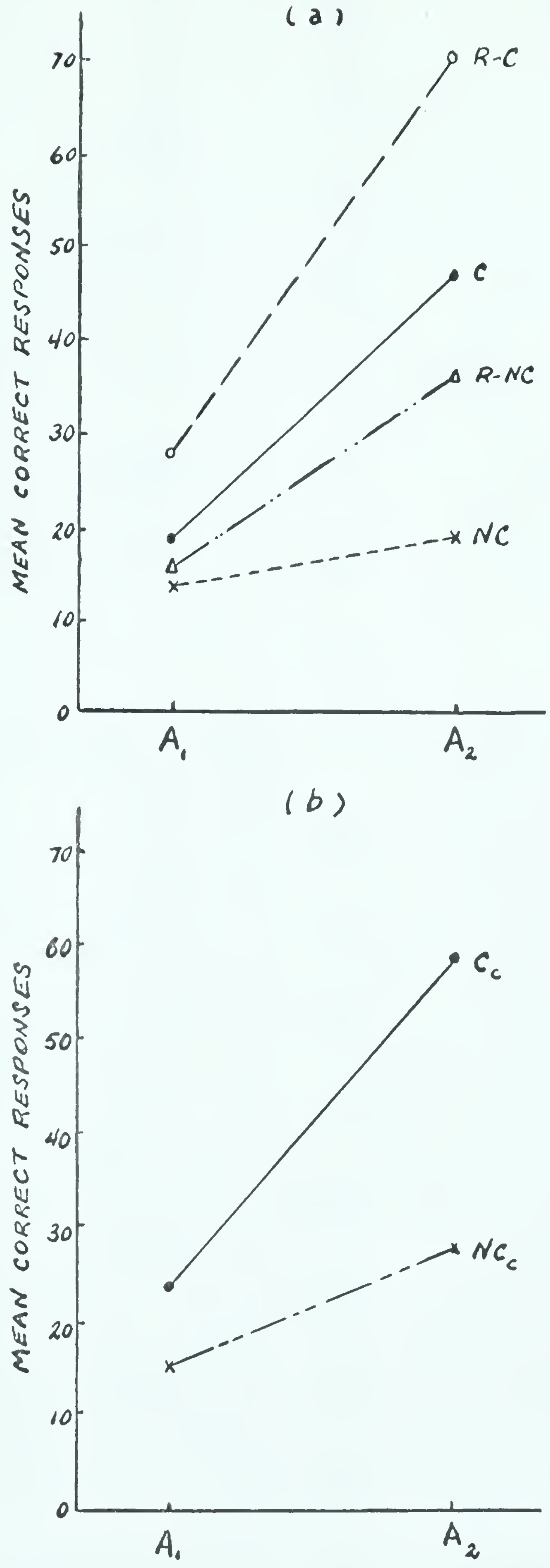

Fig. 4. The A x T interaction in terms of mean correct responses. A_1 = position problem; A_2 = discrimination task.

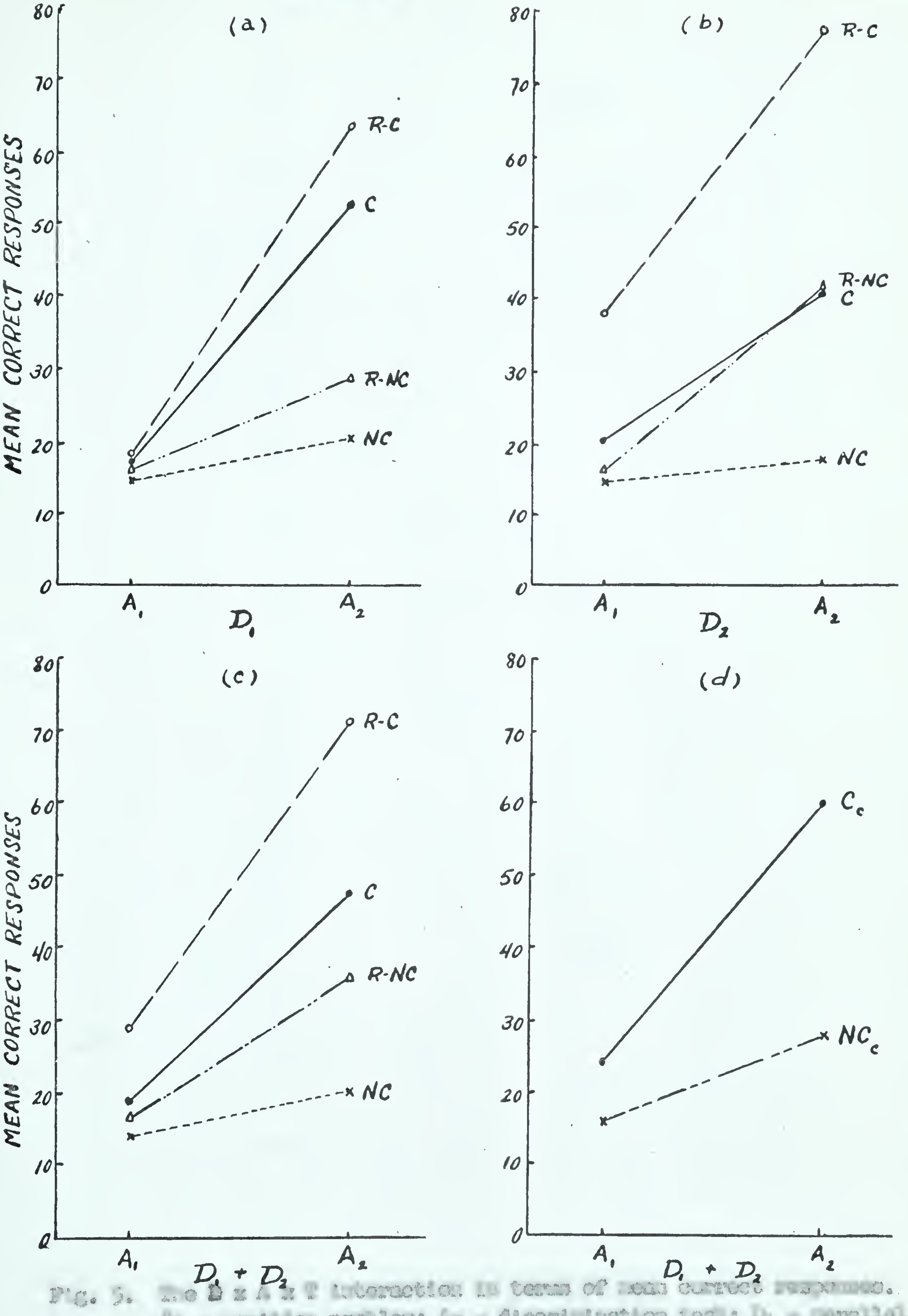

Fig. 5. The D x A x T interaction in terms of mean correct responses. A_1 = position problem; A_2 = discrimination task; D_1 = parallel alley maze; D_2 = T-maze. (a) A x T over D_1; (b) A x T over D_2; (c) A x T over D_1 + D_2; and (d) A x T over D_1 + D_2.

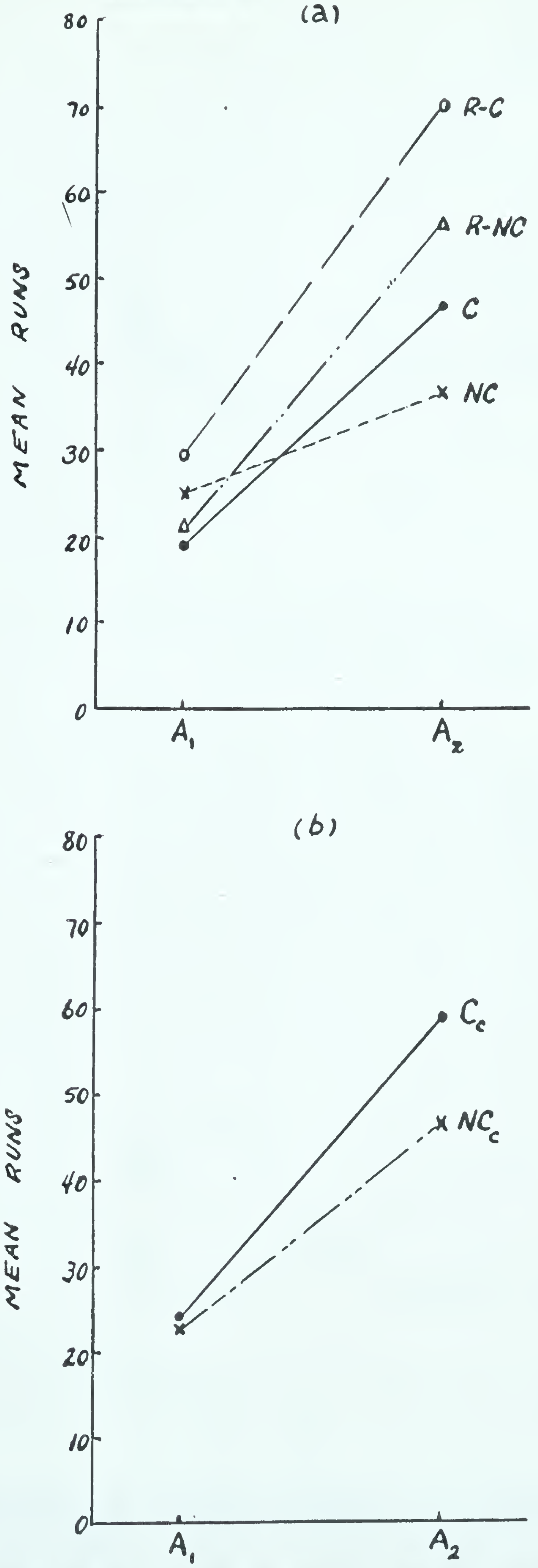

Fig. 6. The A x T interaction in terms of mean number of runs. A_1 = position training problem; A_2 = discrimination task. (a) Separate training methods. (b) Combined training methods.

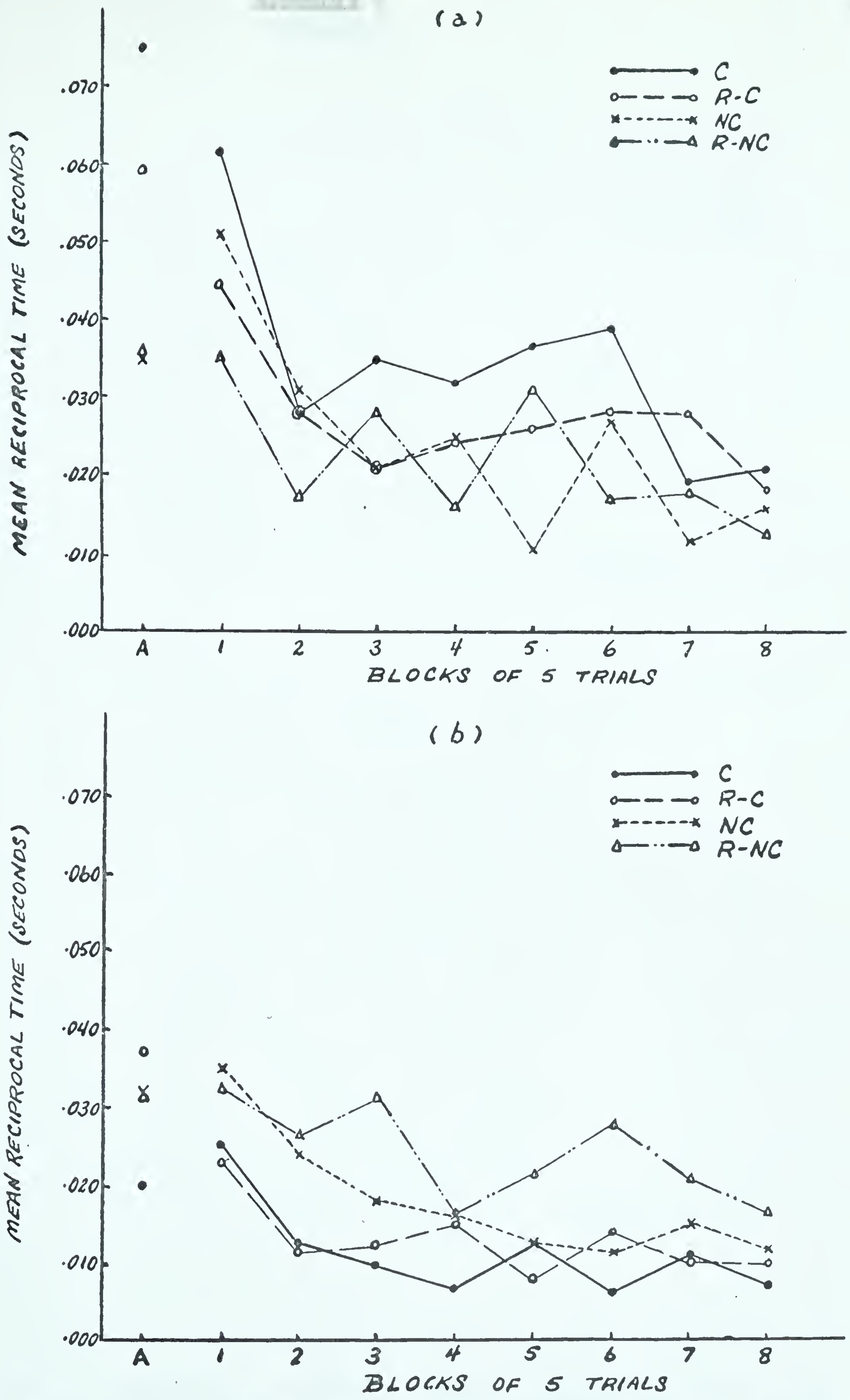

Fig. 7. Comparison of training methods in the extinction of a position habit (A_1) in (a) the parallel alley maze, and (b) the T-Maze in terms of mean reciprocal running time (seconds).

APPENDIX 6

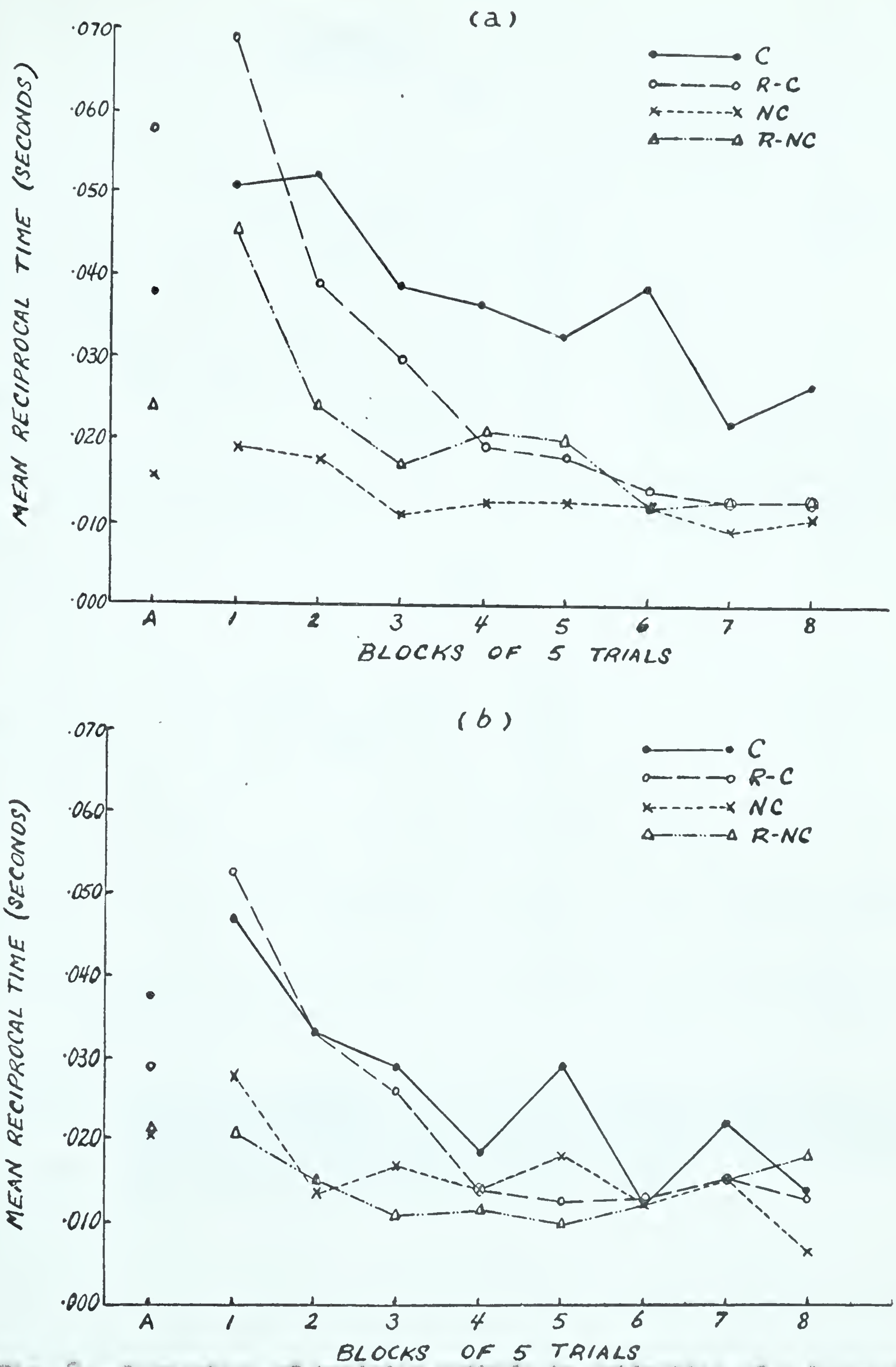

Fig. 6 - Comparison of training methods in extinction of a learned discrimination (A_2) in (a) the parallel alley maze, and (b) in the T-maze in terms of mean reciprocal running time (seconds).

APPENDIX V

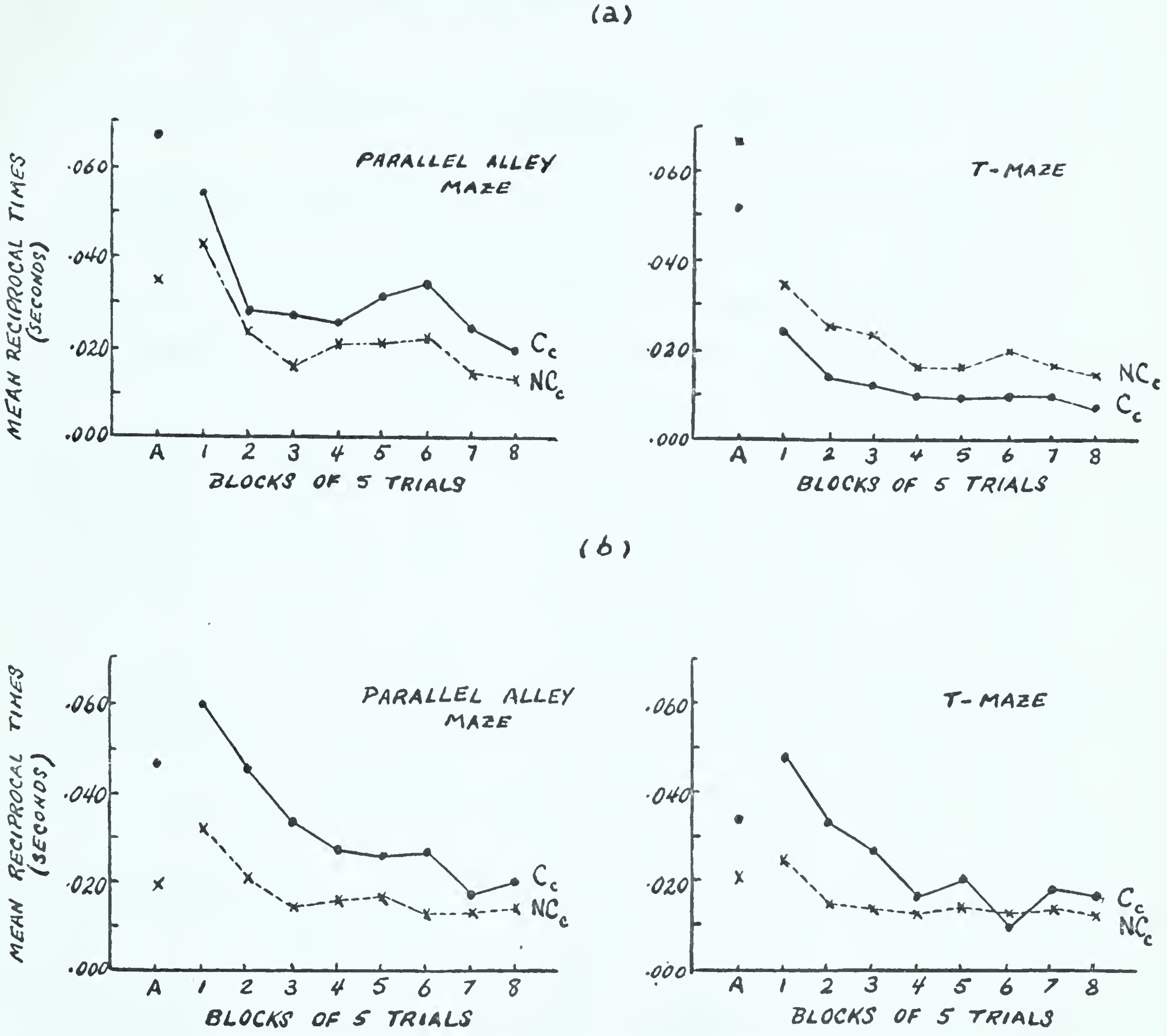

Fig. 9. The average extinction running speeds for Ss trained by the combined correction (C_c) and noncorrection (NC_c) methods in acquisition of (a) the position habit, and (b) the discrimination task using the parallel alley and T-maze.

APPENDIX 10

Table 1

Analysis of Variance of First Choices as Correct Responses in Acquisition

	df	MS	F
Apparatus (D)	1	130.67	
Problems (A)	1	1617.04	2.05
Training Methods (T)	3	71.37	
Preference (P)	1	66.67	
D x A	1	48.17	
D x T	3	58.50	
D x P	1	7.04	
A x T	3	28.38	
A x P	1	10.67	
P x T	3	35.39	
D x A x T	3	23.56	
D x A x P	1	3.38	
D x P x T	3	36.93	
A x P x T	3	57.90	
D x A x P x T	3	7.53	
Treatments	31	916.81	1.16
Replications	2	379.08	
Error	62	789.25	

APPENDIX 11

Table 2

Correlations Between Errors, Correct Responses and VTEs for Combined Correction (C_c) and Noncorrection (NC_c) Methods Under Acquisition of a Position Habit and Discrimination in the Parallel Alley and T-Mazes

Training Method Combined	Problems[1]				Apparatus[1]			
	Position Response		Discrimination		Parallel Alley		T-Maze	
	E.	C.R.	E.	C.R.	E.	C.R.	E.	C.R.
C_c	.21	*.45	.32	.22	*.69	*.50	*.56	*.56
NC_c	.12	*.47	*.47	*.37	*.70	*.63	*.45	.30

*$p < .05$

[1] $n = 24$

E = Error

C.R. = Correct Reponse

APPENDIX 12

Table 3

Correlations Between Errors and VTEs in Extinction and Learned Problems (A_1 and A_2) under Training Methods and Preference Factors in the Parallel Alley and T-Mazes.

		Training Methods[1]				Preference[2]	
Problem	Apparatus	C	R-C	NC	R-NC	Preferred	Non-Preferred
Position Response A_1	Parallel Alley	.22	.42	-.26	.27	-.06	.50
	T	.11	.70	-.22	*.93	.31	.39
Discrimination A_2	Parallel Alley	-.11	.05	-.17	-.53	.00	-.23
	T	-.46	-.16	-.61	.44	.08	-.28

[1] n = 6 per cell

[2] n = 12 per cell

*$p < .05$

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